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ABSTRACT

Two pilot studies, which were conducted to determine the effectiveness of a home-based tutoring program operated within an accredited special function school, and to guide the development of an on-going tutoring research project are presented. The population served, from which study populations are drawn, has included, in over 20 years, 5,000 individuals and 350 certified teachers using a curriculum designed to facilitate tutoring. The two studies involved 19 and 24 subjects, respectively, in grades 2 through adult. The students had received tutoring in reading for varying lengths of time. The results suggest that the greatest increase in reading skill occurs after students have received between 20 and 29 hours of tutoring, with smaller gains occurring after 30 to 45 hours by tutoring. The results suggest that pilot studies are being followed up by a research program in which systematic comparisons of pretutoring and posttutoring outcome results are being made across: (1) tutoring times of 10 to 19 hours, 20 to 29 hours, and 30 to 45 hours; (2) types of subjects--students in grades 1 through 12 or adults; and (3) types of tutoring interventions--academic, job-related, and social-emotional. An attempt is being made to compare outcomes for adults assigned to individual and small-group tutoring. Parental involvement is being studied as a factor in the tutoring of some children. Outcome results are being compared for children whose schools or teachers cooperated in the treatment as against situations where the school or teacher did not cooperate. The last section of this report describes the on-going research program in the context of contemporary developments in cognitive science and instruction. Seven tables and two figures are included. (SLD)

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TUTORING: A DESCRIPTION OF AN ONGOING RESEARCH PROGRAM

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Tutoring: A Description of An On-Going Research Program

Abstract

Given the promising quantitative and qualitative results from a series of small scale pilot studies, a field experiment was designed in an effort to try to explain both the short- and long-term effects of a number of on-going tutoring programs. Systematic comparisons of pre- and post-tutoring outcome results are now being made across experimental conditions (10-19 hours, 20-29 hours, 30-45 hours), across types of subjects (students enrolled in grades 1-12 and adults), and across types of tutoring interventions (academic, job-related, social-emotional) for all participants in the tutoring programs. Attention is being given to coding of the type of intervention (e.g., behavioral, cognitive) along with multiple outcome findings across time blocks. An attempt is being made to compare tutoring outcomes for adult subjects assigned to individual and small group (3-5) tutoring conditions. With some children, situations have been set up where parents are involved vs. situations where parents are not involved. A careful examination of the results is being made comparing the outcome results for those tutees where the school and/or teacher cooperated in the tutoring treatment vs. situations where the school and/or teacher did not cooperate. The last section consists of a description of the research program embedded within the context of contemporary developments in cognitive science and instruction.

Tutoring: A Description of An On-Going Research Program

Gordon (1990) reported that large group based schooling has dominated the twentieth century, but individual and small group tutoring approaches to instruction still hold an important role. Peer-tutors, after-school remedial programs, home-bound instruction, and the "home-schooling movement" are modern expressions of tutoring. Centuries of tutors demonstrated that a child's education was a highly personalized process, supported by the family, and guided through the assistance of literate teachers. At their best, tutors remained the best equipped to assess individual differences among their students and to engineer stimulating learning environments (Gordon, 1990). In the nineteenth and particularly in the twentieth centuries tutoring became an actual part of "schooling." Some of the most important philosophers of the West developed educational theories based upon their practical experience as tutors. Their tutorial philosophy led to the development of many of our modern educational principles such as continuous assessment, remediation, encouragement, and support. It should be noted that these principles are the same as those assumed to be of importance to advocates of mastery learning instruction.

A review of the literature indicates that tutoring usually produces positive results. Annis (1983) reported that tutoring procedures appear to produce good effects on both tutees and tutors. Summarizing research on tutoring, Gage and Berliner

(1988) indicated that these positive effects have been consistently found on cognitive measures of achievement and on affective measures of self-esteem and intrinsic interest in the subject matter being taught. A meta-analysis of the studies of the effects of tutoring (Cohen, Kulik, & Kulik, 1982) indicated an initially high rate of success in a relatively short time (usually measured in weeks), common to achievement gains from tutoring. These initial gains appeared to diminish over time in most studies after four weeks of tutoring. In addition, the results from numerous cross-age, peer tutoring studies conducted with learners across the life span have yielded positive findings (Lippitt, 1969; P. Lippitt & R. Lippitt, 1970; R. Lippitt & M. Lippitt, 1968). In sum, tutoring appears to be a very powerful technique for enhancing student learning across a wide sample of different types of students and instructional areas.

For the past 20 years a home based tutoring curriculum has been operating within an accredited special function school. To date, the population served has included 5,000 individuals. These individuals have been tutored by a faculty of 350 certified teachers utilizing a specially designed curriculum to facilitate the tutorial process. Seven administrative staff have been involved in the selection and training of the tutors, student intake evaluations, case study staffings, and general tutorial supervision. Program offerings have included pre-school, elementary, secondary, college and adult academic and vocational

programs of study. In addition, services have been provided to those seeking social-emotional interventions. The types of tutoring programs have included: academic subject improvement (i.e., basic reading, basic math), social-emotional interventions, treatment of learning disabilities, job-related skills, ESL, and foreign language instruction for assignments overseas.

To facilitate better individualized tutoring across types of subjects (children enrolled in grades 1-12 and adults), a number of specially crafted curriculum scripts were designed to teach student competencies at the introductory, maintenance and/or mastery levels. Over 300 learning descriptors were systematically developed and used to document academic achievement, acquisition of visual and auditory skills, social-emotional outcomes, and selected job-related skills. These learning descriptors were assessed by means of using tutor observations, criterion and norm referenced achievement tests, and personality tests.

An informal evaluation of the program offerings indicated that there were differences in tutoring outcomes across time blocks (0-10 hours, 10-20 hours, 20-30 hours). The assumption was made that these differences occurred because time was needed: (1) to assess how the tutee approached the learning situation; (2) to discover what specific sequential subject matter skills the tutee lacked; (3) to reorganize tutee achievement/study

habits; (4) to assess and improve tutee motivators that supported learning (i.e., improving parental or workplace employer motivators).

Given the findings from the informal evaluation of the program offerings, two research questions were of special interest to the developers of the tutoring program: What effect was the tutoring program having on student outcome measures of achievement? Does the number of hours a student is tutored in the program relate significantly to achievement? It should be noted that the action research project reported here was not originally designed within the context of an experimental design. Initially, a series of exploratory pilot studies were conducted in an attempt to determine the effectiveness of the existing programs where tutoring was blocked into naturally occurring time segments of 10 to 15 hours. The results of these pilot studies led to some interesting but rather puzzling results that prompted further inquiry which ultimately led to the development of the on-going tutoring and mastery learning research project described below.

A Sampling of Pilot Data Findings

Pilot I Data. A sample of nineteen (19) students in grades 2 through adult were selected from existing school records. Students had received tutoring in reading on an average of two hours per week and had been pre-tested and post-tested on alternate forms of the Scott, Foresman Achievement Test in

Reading. The test is reported to have a .95 reliability (KR-20). The 90 test items measure vocabulary and comprehension skills, reflected in ability to understand word and phrase, sentence, and paragraph meaning.

Either Form A or B was administered by the tutor as a pre-test; the alternate form was then administered by the tutor as a post-test. A one-way analysis of variance was applied to the post-test scores on the reading achievement test. The independent variable was the number of hours of tutoring completed by tutees. Three groups of hours were created to follow the natural time blocks in the program: 10-19 hours; 20-29 hours; and 30-45 hours. The analysis of variance results (using the Student-Neuman-Keuls procedure to compare group means) indicated that no pair of group means differed significantly ($p=.5319$). However, the means and standard deviations for pre-test performance by group and post-test performance by group showed substantial gains at 20-29 hours of tutoring and a puzzling drop off at 30-45 hours (see Table 1 for details).

Insert Table 1 About Here

Out of curiosity, a multiple regression analysis was performed to see what might be "teased out" between Group 2 and Group 3. The regression results are reported in Table 2.

Insert Table 2 About Here

Although the overall significance still suggested that number of hours of tutoring was not having a significantly different effect on post-test performance, the effect of the pre-test on post-test performance appeared to be interesting in relation to the effect of the groups.

The significance of the variables within the regression equation (Beta weights) showed consistently that Group 3 influenced the variance in the presence of the pre-test (t=.048). When the effects of the pre-test were removed, Group 3 was found to be significant (t=.00). However, when the pre-test was entered into the regression formula itself, the pretest was also found to be significant (t=.003).

These pilot results raised several concerns. The sample size was one concern, as was the possibility of the pre-test working as a covariate. The reading program developers decided to improve their pre-test/post-test procedures, to continue collecting data, but more systematically, and to increase the sample size.

Pilot II Data. The sample size was increased to 24; this is still a small sample, but the developers of the tutoring program in reading were mostly interested in the effect, if any, of adding to the sample. A one-way analysis of variance was applied

again to post-test scores on the reading achievement test. Variables were the number of hours completed by tutees. Once again, three groups of hours were created to follow the natural time blocks in the program: 10-19 hours; 20-29 hours; 30-45 hours.

The analysis of variance results (using the Student-Neuman-Keuls procedure to compare groups means) indicated that no pair of group means differed significantly (p=.1989). However, the significance had increased notably. Overall, the number of hours of tutoring in reading did not appear to make a significant difference in post-test performance. However, means and standard deviations (see Table 3 for details) for post-test performance by group again showed substantial gains at 20-29 hours of tutoring.

Insert Table 3 About Here

It is interesting to note that the mean for Group I (10-19 hours) was below the overall pre-test mean (55.96). As noted earlier, a meta-analysis of studies of the effects of tutoring (Cohen, Kulik, & Kulik, 1982) indicated an initially high rate of success in a relatively short time (usually measured in weeks), common to achievement gains from tutoring. These initial gains appeared to diminish over time in most studies after four weeks of tutoring. What the means suggested here was that the greatest increase in reading achievement occurred not in Group 1 but in

Group 2 (20-29 hours). After 30 hours of tutoring, the gains in mean appeared to diminish.

With the increased overall insignificance of the effect of the number of hours on post-test performance, a regression analysis was used again to determine the separate effects, if any, on post-test performance across number of hours of tutoring. A summary of the regression results is presented in Table 4.

Insert Table 4 About Here

Putnam (1987) reported that the number of hours of tutoring in a reading program was connected to the notion of the development of a long term "curriculum script." Were some long term effects being reflected in the effects of the pre-test and Group 3?

The significance of variables within the regression equation (Beta weights) again showed that Group 3 influenced the variance in the presence of the pre-test (t=.16). When the effects of the pre-test were removed, Group 3 was significant (t=.00). When the pre-test alone was entered into the regression formula, the pre-test was also significant (t=.013). When the pre-test and Group 3 were entered into the formula together as covariates, the effects were also found to be significant (t=.011).

An examination of the correlations (see Table 5 for details) among post-test scores, number of hours of tutoring, and pre-test

scores suggested several points of interest for further inquiry. Post-test and number of hours in Group 2 (20-29 hours) correlated positively (.326), but the post-test correlated negatively with Group 1 (-.357) and Group 3 (-.647). These findings may reflect the consistent appearance of an increase in the post-test mean for Group 2.

Insert Table 5 About Here

But, the post-test also correlated positively (.510) with the pre-test. The pre-test seems here to be a good predictor of reading achievement at 20-29 hours of tutoring.

The pre-test correlated negatively, however, with Group 1 (-.594). The early initial gains found in other tutoring studies did not seem to hold here. The pre-test was not found to be a good predictor of achievement in initial tutoring hours (Group 1). However, the pre-test did correlate positively with Group 2 (.292) and with Group 3 (.378). These findings suggest looking into the pre-test as a predictor of long term gains with increased hours of tutoring.

Also of special interest were the correlations among groups. Group 1 correlated negatively with Group 2 (-.650) and positively with Group 3 (.953). Group 2 also correlated positively with Group 3 (.964). Once again these findings suggest looking into a long term, perhaps cumulative, effect of tutoring.

Summary of Pilot Findings

In addition to the rather promising quantitative results from a series of small scale pilot studies similar to those reported above, qualitative evaluations (i.e., tutee, tutor, teacher, and/or employer evaluations) indicated significant growth in student academic skills, study skills, and numerous positive motivational changes related to learning in general, academic learning, school, and work. Two key motivational factors appeared to be the close proximity to a support environment (family/home/workplace) and individual perseverance. Long-term qualitative follow-up studies indicated that the majority of students retained what they learned while being tutored. Tutee attitudes toward study, personal motivational levels, and individual achievement showed consistent improvement after enrollment in the tutoring programs of study.

In light of the data from a series of pilot studies similar to those just described, the developers of the tutoring program decided to continue collecting data in an on-going action research project. The overall analytic paradigm presented in Table 6 was developed, and the sample size was increased in an effort to try to explain further both the short- and the long-term effects of the tutoring programs. In addition to compiling pre- and post-test outcome results for all participants, tutee (student and/or employee); local school, and/or employer; parental, and/or peer quantitative and qualitative evaluations of

tutoring outcomes are now being systematically compiled. In addition, comparisons of the quantitative and qualitative evaluations across tutees, tutors, regular teachers, and employers are now being made. Comparison of pre- and post-tutoring outcome results are now being made across experimental conditions (10-19 hours, 20-29 hours, 30-45 hours), across types of subjects (students enrolled in grades 1-12 and adults), and across types of tutoring interventions (academic, job-related, social-emotional) for all participants in the tutoring programs.

Insert Table 6 About Here

Presently, a quantitative and qualitative analysis of the existing data base is underway. Particular attention is being given to coding of the type of intervention (e.g., behavioral, cognitive) along with multiple outcome findings across time blocks. In addition, an attempt is being made to compare tutoring outcomes for adult subjects assigned to individual and small group (3-5) tutoring conditions. With some children, situations have been set up where parents are involved vs. situations where parents are not involved. Finally, a careful examination of the results is being made comparing the outcome results for those tutees where the school and/or teacher cooperated in the tutoring treatment vs. situations where the school and/or teacher did not cooperate.

A Description of the Research Program Within the Context of Contemporary Developments in Cognitive Science and Instruction

A Behaviorally Based Mastery Learning Anchor. John B. Carroll (1963) proposed that degree of learning is a function of the ratio of two quantities: the amount of time a learner spends on the learning task and the amount of time a learner needs to learn the task.

Insert Figure 1 Here

Carroll's model is depicted in Figure 1. This model has served as a behaviorally based theoretical anchor for much of Bloom's (1968) work related to mastery learning instruction. Carroll's formulation implied that by allowing sufficient time to learn a task (i.e. permitting the numerator of the ratio to be larger), and by improving instructional conditions (i.e. decreasing the denominator), most students should be able to reach the mastery criterion. Mastery learning is an educational procedure in which a learning hierarchy is developed and learners are required to master each unit of the hierarchy prior to beginning a subsequent unit. Mastery is usually determined by end-of-unit tests which learners must pass. Bloom (1971, 1976) has argued that mastery learning research (Block, 1971, 1974; Block and Burns, 1976) appears to support his claim that mastery learning strategies can raise the achievement levels of

approximately 80% of students to levels achieved by the upper 20% under non-mastery conditions. It should be noted that these findings apply to many academic content areas (e.g. reading, writing, and math) and different types of thinking and problem solving situations. From these reviews, it seems that most investigators recognize that the tutoring and mastery learning research findings confirm the achievement claims, but that the time claims require further investigation. Most tutoring and mastery learning theorists acknowledge that during the initial learning sequences, extra time must be provided to less able learners. However, this extra time is viewed by tutoring and mastery learning advocates as a temporary crutch which becomes less and less necessary with practice (Bloom, 1976).

A number of critics of mastery learning instruction (Anderson and Burns, 1987; Buss, 1976; Greeno, 1978; Guskey, 1987; Mueller, 1976; Resnick, 1977; Slavin, 1987a, 1987b) have argued that in regular non-mastery school situations in which time is held constant for all learners, individual differences among students are reflected primarily in differences in achievement outcomes. That is to say that if all students are restricted to learning a lesson in a certain amount of time, then a normal distribution of high, average, and low achievement scores will probably manifest itself. However, if achievement outcomes are held constant in mastery learning instruction, then individual differences between learners will be reflected by

differences in the time needed to learn. Another way of stating this situation is to say that the assumption of stability in individual differences among students is directly related to the assumption of a time-achievement trade-off. To bring less able learners up to the desired mastery level, additional time must be provided for both learners and teachers. Since individual differences between learners are assumed to be relatively stable, critics claim that these time costs remain relatively constant throughout mastery learning instruction (i.e. time is traded for increased achievement of less able students and time inequality is traded for achievement equality).

There is considerable evidence indicating that the effectiveness of the mastery approach depends on the length of the experiment and the type of outcome measure used. Slavin (1987a) found that experiments lasting four weeks or longer yielded more positive findings than those experiments lasting less than four weeks. It should be noted that standardized achievement outcome measures yield much weaker results than curriculum based outcome measures (Slavin, 1987a) and that group based mastery learning approaches appear to be extremely difficult to carry out with success in inner city schoools (Brophy, 1988). Finally, there may be a "Robin Hood effect" associated with the use of mastery learning approaches to instruction; mastery learning may help slower-learning students at the expense of faster-learning students. The important

educational resources of teacher time and attention may be used to benefit the slower learners at the expense of faster ones.

A Cognitive Science Model of Tutoring and Mastery Learning. It is our view that it is now time to embellish the behaviorally based mastery learning model originally proposed by Carroll (1963) to include a number of cognitive variables. An embellished cognitive science model of tutoring and mastery learning instruction is presented in Figure 2.

Insert Figure 2 Here

From a cognitive scientists' perspective, individual differences in student aptitude would consist of differences in attention, temperament, maturational stages of development, existing knowledge and language templates, cognitive styles, attitudes, expectancies, and mood. Quality of instruction would relate to the ability of the teacher to organize instruction, to set up situations which would enhance meaning and contribute to the development of critical thinking and problem solving skills.

It is recognized that we are unable to modify biological differences in temperament and maturational stages. But most of the components listed in the embellished cognitive science model can be learned. We can enhance knowledge and language templates. It is generally accepted that how efficiently we learn depends to a great extent on what we already know. From a cognitive

perspective, a major constraint on an atypical learner is that their knowledge base and ability to use language to code and store information is very limited. There is a literate bias in schooling which is viewed as enhancing our thinking and problem solving behaviors. The assumption is that this literate bias allows the expert learner (artist, writer, reader) to interpret environmental events (a painting or story) in a different way than the novice learner. It is further assumed that the student with an internally controlled, field independent cognitive style interprets their environment in a way that differs from the externally controlled, field dependent learner. For example, the internally controlled student would attribute their successes to effort, persistence, and hard work while the externally controlled student would be more likely to attribute their successes to luck. Negative attitudes, low expectancies, and bad moods constrain cognitive performance. Again, the point to be made here is that knowledge and language templates, cognitive styles, attitudes, expectancies, and mood can be modified by the tutor.

Summary

In an attempt to specifically relate the conceptual model to the research project at hand, a number of procedural components peculiar to the ongoing tutoring program are listed in Table 7.

Insert Table 7 About Here

Given what was described above, the developers of the tutoring programs are assuming that the general dynamics of learning appear to be the same for all learners (i.e., we all learn through some combination of classical conditioning, operant conditioning, social learning, and/or cognition). From an information processing perspective, differences in learning characteristics across typical and atypical learners are assumed to manifest themselves in differences in attention, cognitive style expectancies (field dependence - field independence, internal-external locus of control), and memory organization (with emphasis being given to the primacy of proactive interference and transfer). With respect to constraints on learning and development, it is assumed that biological constraints consist of attention, temperament, and maturational stages of development. Psychological constraints are viewed as consisting of existing language and knowledge templates, cognitive styles, attitudes, expectancies, and mood. Of special interest here is a broadened view of educational, psychological, and social constraints related to the tutor, the tutee's family and social support system, the tutee's school and/or place of employment. Finally, with respect to addressing the question, What develops?, it is assumed that attention develops, M-power,

executive processes, and metacognition develop. With respect to addressing the questions, When do we learn? and What is the relationship of new learning to existing cognitive structures?, the assumption is made that we learn when we acquire a rule, preferably a verbal rule, which relates new learning to what we already know.

One might get the impression that we are assuming a diagnostic-prescriptive framework for improving the achievement of learners. However, this is not the case. It is recognized that the current thinking in special education curriculum and instruction departs from the diagnostic-prescriptive model at least for the mildly and moderately handicapped learner because it focuses narrowly on deficits, does not recognize and build on strengths, and does not consider the complexity, connectedness, and wholistic nature of learning.

Much of what is presented here is derived from the field of cognitive information processing, a field replete with overlapping ideas and concepts expressed in multiple terms. There are those practitioners who would claim that the field is too difficult and the instructional procedures derived from it too cumbersome to use. While most of us may agree that educators should utilize cognitive information processing principles in the curriculum and instructional designs they create for all learners, we may not think that this complex theory of learning and instruction is suited to tutoring where novice educators (the

tutors) are expected to monitor and shape the cognitive information processing capabilities of learners. Some may also claim that the information processing procedures are not suited to tutoring and mastery learning instructional situations where students usually work in isolation or with teachers on individual learning tasks.

At first glance the possible utility of the embellished cognitive science model of tutoring and mastery learning instruction may not appear to be clear. We may have a conceptual understanding of each variable, but not the possible interrelationships. For example, how does one multiply the ability to understand by the quality of instruction in a practical setting? What does the model mean to a busy educator concerned about how to improve student performance?

What we are proposing here is a general information processing approach to instruction. Cognitive information processing is enhanced when learners are actively engaged in the learning task, discuss, rehearse, analyze, problem solve, use graphs to represent experience, and share observations, understandings, and knowledge. The overall thesis is that when we are called upon to design tutoring and mastery learning environments, we should attempt to include instructional procedures having potential for the modification of the cognitive components (attention, knowledge and language templates, cognitive strategies) presented in the model. The potential

ramifications are many for instructional improvements. We know that tutoring and mastery learning instructional systems work. The two instructional systems have been carefully tested in highly controlled laboratory, field experimental, and applied settings. What is now needed is a greater focus and appreciation for attempts to relate recent findings in cognitive science to these behaviorally anchored models. It is our view that greater sensitivity to the possibility of relating cognitive variables to our existing behavioral models of tutoring and mastery learning will enhance instructional options and better account for and minimize individual differences in learning.

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Table 1

	Pre-test Mean	Pre-test S.D.	Post-test Mean	Post-test S.D.
Group 1 (10-19 hours)	45.1	12.7	55.1	17.2
Group 2 (20-29 hours)	59.0	11.4	64.0	11.6
Group 3 (30-45 hours)	68.2	18.4	62.6	16.0

N=19

Table 2

Variable	Multiple R	R^2	F	Sig F
Groups + Pre-test	.366	.134	.775	.526
Groups alone	.275	.076	.657	.532
Pre-test alone	.341	.116	2.230	.153

Table 3

	Pre-test Mean	Pre-test S.D.	Post-test Mean	Post-test S.D.
Group 1 (10-19 hours)	45.54	11.8	54.0	15.8
Group 2 (20-29 hours)	62.62	13.1	68.5	18.8
Group 3 (30-45 hours)	68.2	18.4	62.6	16.0

N=24 F ratio = 1.7457 Sig F = .1989

Table 4

Variable	Multiple R	R^2	F	Sig F
Groups + Pre-test	.546	.298	2.83	.064
Groups alone	.377	.143	1.74	.199
Pre-test alone	.510	.260	7.73	.011

Table 5

	Post-test	Group 1	Group 2	Group 3	Pre-test
Post-test	1.0	-.357	.326	-.647	.510
Group 1		1.0	-.650	.953	-.594
Group 2			1.0	.964	.292
Group 3				1.0	.378
Pre-test					1.0

Table 6

Overall Analytic Paradigm

	Treatment Conditions					
	Xa1 Time Block I 10-19 Hours		Xa2 Time Block II 20-29 Hours		Xa3 Time Block III 30-45 Hours	
Subject Type Xc1 Grade 2 to Grade 12 Adult	Yb	Ya	Yb	Ya	Yb	Ya
Subject Type Xc2 Grade 2 to Grade 12 Adult	Yb	Ya	Yb	Ya	Yb	Ya
Adult	Yb	Ya	Yb	Ya	Yb	Ya

Where: Independent variables:
- treatment condition time blocks Xa1, Xa2, Xa3
- type of intervention Xb1, Xb2, Xb3
- subject types Xc1, Xc2, Xc3

Dependent variables:
- academic, social-emotional and, job-related pre- and post-test outcome measures
- triangulation of quantitative and qualitative tutor (student and/or employee), local school and/or employer, parental and/or peer evaluations of tutoring outcomes

Table 7

A Summary Outline of the Relationship of the Conceptual Model to the On-Going Research Program

Experimental manipulation of time spent (pilot results indicate the importance of 20-30 hours of instructional intervention)

Systematic manipulation and continuous tracking of flexible control structures (organization of instruction; use of mathemagenic activities, mnemonics, strategy training procedures) across types of subjects (students enrolled in grades 1-12 and adults), and across types of tutoring interventions (academic, job-related, social-emotional) for all participants in the tutoring programs.

An on-going attempt is being made to relate developing knowledge in cognitive science (task analyses, educational interventions, intelligence, discourse comprehension-prose learning, assessment of learning outcomes, path and criterion referenced assessment procedures, cognitive-behavior modification) to instructional interventions.

A carefully monitored test-tutor-test information processing instructional system design model is used to facilitate and document mastery.

Employment of a continuous feedback loop of reliability checks on the data enhances accuracy of documentation of improvement in performance.

The overall focus of the project is on the enhancement of the quality of instruction with a special emphasis given to the social interactions taking place among the participants.

Figure 1

Carroll's Model of Mastery Learning

$$\text{Degree of learning} = \frac{\text{amount of time spent on a task}}{\text{amount of time needed to learn the task}}$$

Figure 2

An Embellished Cognitive Science Model of Tutoring, Mastery Learning, and PSI Instruction

$$\text{Degree of learning} = \frac{\text{time spent (willing or allowed)}}{\text{time needed (aptitude, i.e., individual differences) + (quality of instruction x ability to understand instructions)}}$$

Where: Student aptitude would consist of the biological differences of attention, temperament, and maturational stages of development and the psychological differences of existing knowledge and language templates, cognitive styles, attitudes, expectancies, and mood.

Quality of instruction would be viewed as the ability of the teacher to organize instruction, to give it meaning, and to set up problem solving situations which enhance critical thinking.

Ability to understand instructions would consist of the same components as quality of instruction.